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Wireless sensor networks simulators – computer simulation tools

Igor Georgioski and Hristina Trenchevska

Faculty of information and communication technologies, Partizanska bb, 7000 Bitola, Macedonia
i_georgioski@hotmail.com, htrenchevska@yahoo.com

Abstract. With the development of embedded systems and network technologies there was a need to find a device that will be used for measurements and at the same time it will be economical. Wireless sensors, using self-configuring sensors are perfect for this purpose. With the sensors it was ensured traceability of the physical conditions of the environment (temperature, humidity, vibration, pressure, sound, movement, etc.) with very low power consumption and high precision. The sensors also have the ability to transmit and return data to a base station. But before implementing, you have to use the simulator to test these sensors, especially in the initial phase of these designs. The cost to simulate thousands of nodes networks is very low, and the simulation can be completed in a short time. Therefore, simulation of WSN is of great importance for the development of WSN. Protocols, schemes or even new ideas can be assessed in very large sizes. WSN simulators allow users to isolate different factors with setting up configurable parameters. In this paperwork we have used two simulators: Network Simulator 2 and Omnet++.

Keywords: network simulators, wireless sensors, information system, embedded systems, sensors

1. Introduction

Wireless sensor networks are networks that consists a large number of sensor nodes wirelessly connected to each other and to the base station. [1] The beginnings of wireless sensor networks are even from Cold War, and were firstly invented from the United States. This technology was upgraded in the mid-1980s when the Institute of Technology in Massachusetts developed DSN which consisted of acoustic sensors designed to monitor low flying aircraft. There are many factors that affect the design of wireless networks. When a designer is designing protocols for WSN he must consider these factors. Also, he can use simulation. That is an important approach in the development and evaluation of systems in terms of time and cost. The simulation shows

the expected behaviour of the system based on the simulation model under different conditions. In this paper we have used NS2 (Network Simulator v. 2) and Omnet ++ v4.6 simulators. We have simulated one event in each of this simulators. The second simulator Omnet++ is also integrated with the famous program for maps, Google Earth. At the end of this paper, we have submitted the results of this simulations.

2. Wireless Sensor Networks

The wireless sensor network consists a large number of sensor nodes wirelessly connected to each other and the base station, which connects the sensor nodes with another network. [9] Sensor networks find great use and entirely new field of research, which is currently growing rapidly. However, for all this to be put into use, requires huge resources, and it is not allowed the slightest mistake. Therefore, before being placed into use and implement, we need to test or simulate. That is why companies for manufacturing and implementation of wireless sensor networks develop software solutions called simulators.

2.1. Beginnings and development of wireless sensor networks

The beginnings of sensor networks were initiated even during the Cold War by the United States. [9] A network of acoustic sensors were placed in strategic locations at the bottom of the ocean to detect and track submarines of the Soviet Union. This system of acoustic sensors was called Monitoring System sound (Sound Surveillance System-SOSUS). During the same period, the United States also deployed networks of radars against air defence. These sensor networks use hierarchical processing, where data is processed in different layers until the data reach the user. In the mid-1980s, the Institute of Technology in Massachusetts developed DSN which consisted of acoustic sensors designed to monitor low flying aircraft.

2.2. Factors affecting the design of wireless sensor networks

In the wireless sensor networks can be incorporated other types of sensors, including: temperature sensors, vibration, infrared and acoustics. WSN applications differ greatly from one another, there are some common factors that affect all WSNs. These include: reliability, scalability, production costs, network topology, operating environment, media transmission and consumption. [9] When a designer is designing protocols for WSN must take into account these factors.

2.3. Standards for wireless connectivity

In March 1999, IEEE established 802.15 working group as part of the IEEE Computer Society's 802 Local and Metropolitan Area Network Standards Committee. 802.15

working group was established for the specific purpose for developing standards for short wireless networks, known as a personal wireless network (Wireless Personal Area Network- WPANs). Within the 802.15 working group there are four target groups. Target group number one (802.15.1) defines the standard for WPAN based on the physical (PHY) and MAC layer of Bluetooth version 1.1. Target group two (802.15.2) develops a model for coexistence of WLAN (802.11) and WPAN (802.15). The group's goal three (802.15.3) to develop standards for massive data in WPAN (20Mbps and higher). The target group four (802.15.4) is responsible for developing standards of physical (PHY) and MAC layer for Low data rate. [10]

2.4. Simulation model

Simulation is an important approach in the development and evaluation of systems in terms of time and cost. The simulation shows the expected behaviour of the system based on the simulation model under different conditions. The purpose of any simulation model is to determine the exact model and predict its behaviour in practice. For simulation in this paper, we have used NS2 (Network Simulator v. 2) and Omnet ++ v. 4.6. NS2 is a simulator that uses discrete event simulation, an open software, general simulator, that can simulate over 100 nodes. NS-2 cannot simulate problems of bandwidth or power consumption in WSN. Its newest version is NS-3. It is popular in academia for its extensibility (due to its open source model) and plentiful online documentation. NS is popularly used in the simulation of routing and multicast protocols, among others, and is heavily used in ad-hoc networking research. NS supports an array of popular network protocols, offering simulation results for wired and wireless networks alike. It can be also used as limited-functionality network emulator. NS is licensed for use under version 2 of the GNU General Public License [3].
The Omnet++ discrete event simulation environment has been publicly available since 1997. It has been created with the simulation of communication networks, multiprocessors and other distributed systems in mind as application area, but instead of building a specialized simulator, Omnet++ was designed to be as general as possible. Since then, the idea has proven to work, and Omnet++ has been used in numerous domains from queuing network simulations to wireless and ad-hoc network simulations, from business process simulation to peer-to-peer network, optical switch and storage area network simulations.
Omnet ++ is a simulator that uses simulation with discrete event, it has commercialized a license for open source and online documents, general simulator, supports MAC simulators and some localized protocols of WSN simulators, it can simulate the consumption of power and control channel and has limited protocols. [8] NS2 runs on Windows XP environment so we had to use a virtual machine (Oracle VM Virtual Box) on which you install the operating system, while Omnet ++ works on the latest version of Windows, Windows 10.

3. Examples

3.1. Network Simulator v. 2 (NS2)

NS2 is a simulator that is written in C++ and Python. [3] To star the simulator, first open Command Prompt (Start> Run> cmd) and with commands cd desktop/ns. Next command that you need to ask is ns nameoftheproject.tcl (with the command ns we are starting the program and .tcl is the simulation extension) [4]. CMD provides information how many nodes are included in the simulation and what nodes will or won't be affected by the simulation. After executing the last command, we can see the simulation.

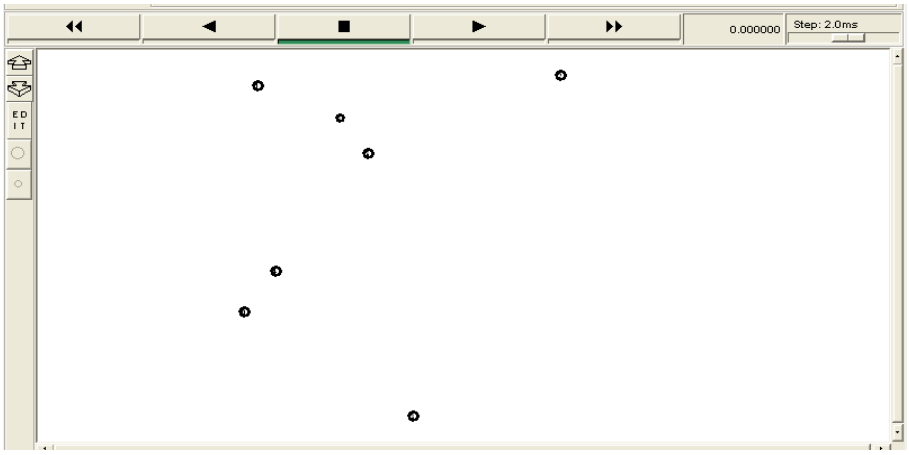

Fig. 1. Starting position of the nodes

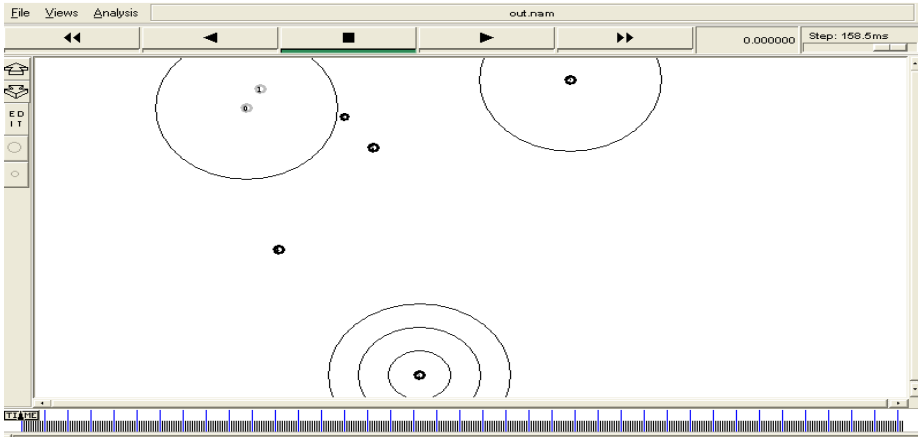

Fig. 2. Operation of the nodes during the simulation and movement of nodes 1 and 2 to their final destination

Table 1. Characteristics of the NS-2 simulation

Number of nodes	Range of each node	FTP transmitters	Field size	Duration of the simulation	Final result
7	250 meters	2	1000m x 1000m	400 seconds	32 seconds

In this simulation we have included the conduct of the Ad Hoc network with 7 nodes [5]. In this scenario, node 0 has to reach destination node 5, while the node number 1 has a destination at node number 6. Nodes 2, 3 and 4 are intermediate nodes. The range of each node is 250 meters. Two of the nodes (node 2 and 3) are FTP transmitters. The simulation is performed in case with this parameters: size 1000m x 1000m, duration of the simulation is 400 seconds, FTP 1 begins at 10 seconds and ends at 300 seconds, while FTP 2 begins at 20 seconds and ends at 400 seconds. The time needed for all nodes to reach its final destination is 32 seconds. To create a new simulation in the simulator, we need to open the .jar library Scenario> New wireless scenario. [7] A new window appears in which we have several options (Hand, Node, Agent, Application, Parameters and TCL). When we add all nodes and set all the options we need and want for simulation, we are free to choose the menu TCL. It will show the code that will be generated, and gives us the option to save it. [6]

3.2. Omnet++ v. 4.6

The simulator will start with double click on the mingwenv.cmd file, and after that a command prompt will be opened. After typing all necessary commands, Omnet ++ will start.

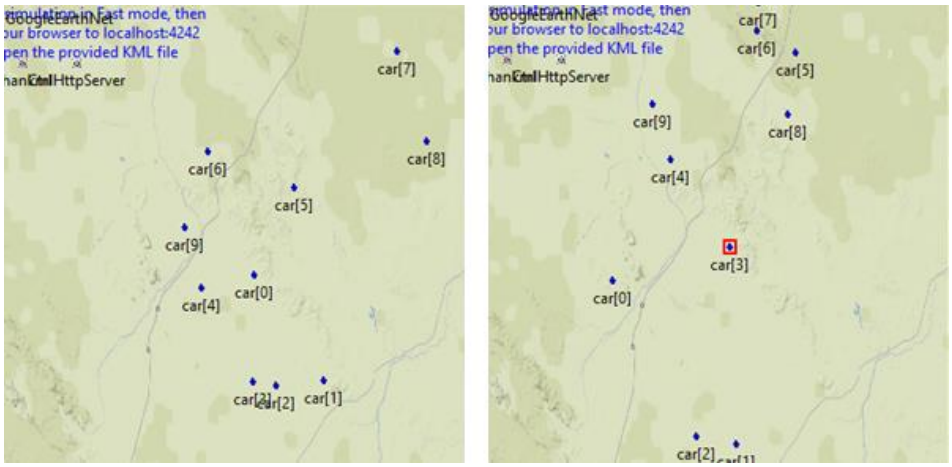

Fig. 3. Starting position of the cars and packet traveling

Table 2. Characteristics of the Omnet++ simulation

Number of nodes	*Range* of each node	FTP transmitters	Field size	*Number of events*	Final result
10	500 meters	2	2000m x 2000m	21	0.1 seconds

The purpose of this simulation is a simulation of a wireless mobile ad hoc network. The model contains 10 mobile nodes (which in this case are represented by cars) that run on their own random area of 2000m x 2000m. Nodes have similar settings, each node can range over an area of 500m. When two nodes meet, they can communicate with each another, forming an ad-hoc network (T\the term ad hoc networking typically refers to a system of network elements that combine to form a network requiring little or no planning [2]). The time needed one data to be sent to all nodes in the simulation is 0.1 seconds, and for the data to be transferred from the first node to the end, 21 events will happen. The advantage of this simulation is the ability for visualization in the application Google Earth. The simulation can be seen visually and live in Google Earth, as it can be seen on the next picture **Fig. 4.**

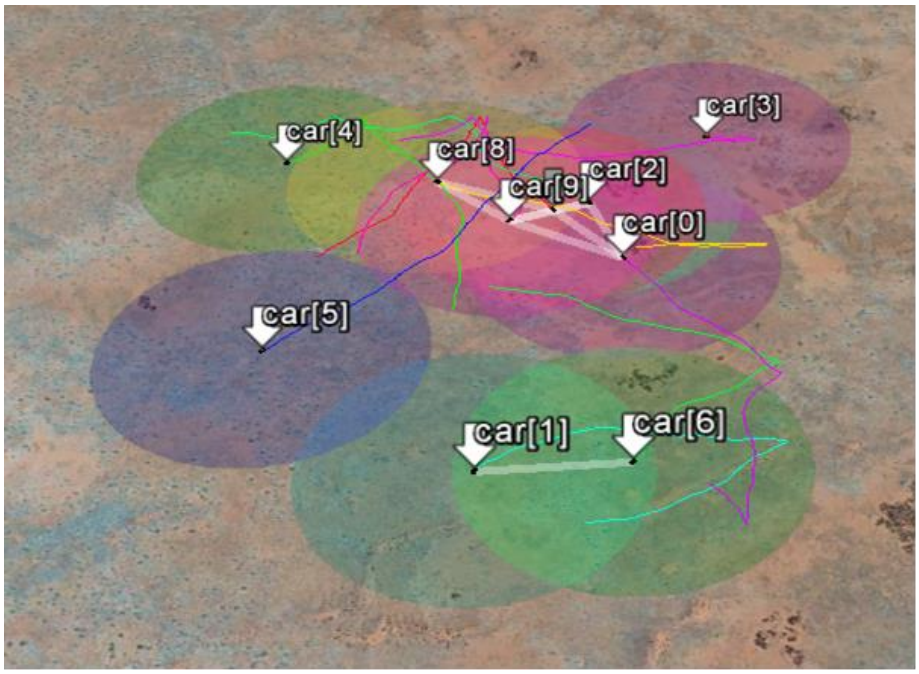

Fig. 4. Omnet ++ simulation Google Earth live preview

4. Conclusion

Wireless sensor networks consist of small knots with capacity for tenderness, calculations and wireless communication. One of the main aspects of sensor networks is that it tends to be application-specific. The advantage of these networks is that they configure themselves, which means that the sensor network can be distributed randomly on the battlefield, in areas where it occurred disasters or inaccessible areas, without the need for a person to have access to them and configure them. Flexibility, high sensitivity, low cost and the quality rapid deployment of sensor networks create many new and existing application areas for remote observations. Ad-hoc technology allows people to be in the conference room where the transmission using infrared or radio frequency wireless signals to link their computers with other computers in the local network with shared data and resources. Each user has a unique network address that is currently registered as part of the network. The technology also includes remote users and hybrid wireless / wired connections. Mobile devices can be connected in any network, anywhere because it eliminated the need for central administration and have great commercial potential. In the future, this broad range of application areas will make sensor networks an integral part of our lives. Omnet++ should be used when we need to visually present the results to the audience, because it offers various graphic interfaces, such as the one used in this simulation, Google Earth. Network Simulator 2 should be used when we want to have more options and to test more simulation scenarios.

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